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Journal of the Franklin Institute 351 (2014) 3503–3507

Journal of The Franklin Institute

www.elsevier.com/locate/jfranklin

Editorial

Editorial of special issue: "Advances in analysis and design of model-based fuzzy control systems" in Journal of the Franklin Institute

Fuzzy-logic-control (FLC) has attracted considerable attention from both the academic and industrial communities over the past few decades. It has been shown to be a simple and effective approach to controlling many complex nonlinear systems or even non-analytic systems. FLC techniques usually describe the complex system by a group of subsystems, according to human knowledge and expertise, and use a simple control law to emulate the human control scheme in each local operation region. The global control law is then determined by "blending" all local control actions through fuzzy membership functions. Because of the complexities of general nonlinear control systems, finding a group of local stabilization control actions is much easier than finding a global stabilization control law. In many cases, FLC is considered as an alternative approach to conventional control techniques. Among various model-based fuzzy control strategies, the method based on the Takagi–Sugeno (T–S) model is well suited for model-based nonlinear control.

The publication of this special issue is to create a forum for scientists, engineers and practitioners throughout the world to present the latest theoretical and technological achievements in analysis and design of fuzzy-model-based control systems. This special issue contains 22 papers, and a brief overview of the papers included is provided as follows.

Luo et al. propose a fuzzy partition based T–S fuzzy systems identification method with block structured sparse representation. It is shown that an accurate description of the T–S fuzzy model can be established with far fewer numbers of fuzzy rules by selecting the important fuzzy rules and eliminating the redundant ones in the process of block structured sparse regression. Some numerical experiments on well-known benchmark data sets are carried out to illustrate the effectiveness of the proposed method.

Yoneyama studies the control design for a class of generalized T–S fuzzy systems, which can be used to describe wider class of nonlinear systems by representing locally nonlinear models. For such a generalized system, a stabilizing controller design method is proposed by introducing a new class of non-PDC controllers. A relaxation method is also used to reduce the conservatism of design conditions. Finally, some simulation examples are given to demonstrate the effectiveness of the proposed method over the existing ones.

Xiang et al. present a new type of switched parallel distributed compensation (PDC) controller via membership function ranking (MFR) scheme for discrete-time T–S fuzzy systems. The MFR scheme can be viewed as an improvement and extension of previous results named latest membership function (LMF) scheme concerned with piecewise quadratic Lyapunov function

http://dx.doi.org/10.1016/j.jfranklin.2014.05.001

(PQLF) approach, since it provides a denser subdivision of normalized membership function space and therefore essentially yields less conservative results. Moreover, it shows that MFR scheme covers LMF scheme as a particular case. A design example is presented to illustrate the advantages of MFR scheme.

Ariño et al. propose a procedure for obtaining poly-topic invariant and contractive sets for closed-loop T–S fuzzy systems. In this work, no assumption on the shape of the membership functions are made, thus the provable sets for valid for any possible membership functions (i.e., results are shape-independent). The results in work justify that the obtained invariant sets are larger than Lyapunov level sets obtained via widely used LMIs with the same linear relaxations of double-sum summations. It is also proved that, if those LMIs were feasible, the proposed algorithm would converge in a finite number of steps and a polyhedral Lyapunov function is obtained. A specific comparison with fuzzy Lyapunov functions is also discussed.

The distributed analysis and design of distributed systems present several advantages, such as modularity, easier analysis and design and reduced computational complexity. Lendek et al. propose conditions for the distributed analysis of T–S fuzzy systems connected in a string. These conditions are also extended to observer and controller design and illustrated on numerical examples.

Wang et al. discuss the problem of the fuzzy sliding mode control for a class of distributed systems. Firstly, a fuzzy auxiliary controller is constructed based on a feedback signal not only to estimate the unknown control term, but also participates in the sliding mode control due to the fuzzy rule employed. Then, the results are extended to the cases where some kinds of system information cannot be obtained. Finally, some typical numerical examples are presented to demonstrate the effectiveness and advantages of the designed sliding mode controller.

Huang et al. develop a novel adaptive state tracking control scheme based on T–S fuzzy models with unknown parameters. The proposed method can deal with T–S fuzzy models in a non-canonical form and allows the numbers of inputs to be less than the state variables, which is more practical and has wider applications. Based on the Lyapunov stability theory, it has been proven that all the signals in the closed-loop system are bounded and the asymptotic state tracking can be achieved. The effectiveness of the proposed scheme is demonstrated through a magnetic suspension system and a transport airplane model.

Guo et al. studies the problem of robust fault detection for a class of discrete-time nonlinear systems, which are represented by T–S fuzzy affine dynamic models with norm-bounded uncertainties. It is assumed that the plant premise variables, which are often the state variables or their functions, are not measurable so that the fault detection filter implementation with state-space partition may not be synchronized with the state trajectories of the plant. Based on a piecewise quadratic Lyapunov function combined with S-procedure and some matrix inequality convexification techniques, the results are formulated in the form of linear matrix inequalities.

Ichalal et al. investigate the problem of fault detection, isolation and estimation for nonlinear systems described by T–S fuzzy models. The aim is to synthesize a residual generator that both minimizes the difference between real and ideal responses and the influence of the disturbance. The minimization problem is formulated by the bounded real lemma and linear matrix inequalities. Simulation examples are given to illustrate the proposed method. Finally, Polya's theorem is also used to reduce the conservatism of the proposed result.

Advanced fault detection and accommodation schemes are required for ensuring efficient and reliable operation of modern wind turbines. Badihi et al. present a novel approach in designing a fault detection and diagnosis and fault-tolerant control scheme for a wind turbine using fuzzy modeling identification and control techniques. The proposed schemes are evaluated by a series